APPLICATION

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MONEY HANDLING MECHANISM WITH PERIPHERAL PORT

The present invention relates to a mechanism for handling money.

Coin or bill handling mechanisms are typically sold to manufacturers of complete machines, such as vending machines, as a unit with a port connectable to a controller within the machine. For example, a coin changer validates coins and outputs a signal on the port indicating the value of acceptable coins received. The machine controller receives signals from a user interface indicating the goods selected, determines the price of the goods, compares the price with the value of coins received, and determines whether there has been an overpayment. If so, the machine controller sends a signal to the changer port indicating the value of change to be given. The changer or the machine controller determine what combination of coins is to be dispensed to make up this value, and the changer dispenses that combination of coins.

Certain standards have been agreed for the physical and electrical connection of peripheral devices to machine controllers. One such standard is the 'International Multi-drop Bus Interface Standard'(the MDB standard). According to this standard, the vending machine controller and peripheral devices are each connected to a common bus. Signals exchanged on the bus comply with a protocol defined by the standard and allow commands to be issued to the peripherals by the vending machine controller and status reports to be sent back by the peripherals to the controller.

However, there are many vending machines already in use in which the input/output port of the vending machine controller complies with an obsolete standard or does not support multiple peripherals, so that the machine cannot be upgraded by adding peripherals.

With the introduction of the Euro, there will be a need to add peripherals for validating Euro banknotes to machines which currently can accept only coins. There will also be a greatly increased need for machines to accept payment in more than one currency. Moreover. as the use of pre-paid or debit cards becomes more widespread, but cash continues to be used, there will be a need to add card readers to machines which currently accept only cash.

According to the present invention, there is provided a first money handling unit which has a first port for connection to a machine controller and a second port for connection to a second money handling unit. In this way, at least one further unit may be added to a machine without the need to alter the interface between the machine controller and the first unit.

According to one aspect of the present invention, the second port is connectable to any one of a number of different money handling units, and may implement a single standard interface for such a connection. An advantage of this arrangement is that, where the machine controller is not able to communicate directly with multiple different types of money handling unit, the first money handling unit according to this aspect of the invention provides the required connectivity instead.

In embodiments of the invention, the first money handling unit is a changer which validates and dispenses coins or tokens, while the second money handling unit may be a banknote validator, a card reader or a further changer, for example.

The interface across the second port may implement a different protocol from that implemented across the first port, and the first unit then converts signals between the two protocols. In this way the second unit, although incompatible with the controller, may be used in the same system as the controller.

According to a second aspect of the invention, the interfaces across the first and second port may implement the same protocol and the second unit may be physically connectable either to the second port or directly to the controller, for example via a bus connection. When the second unit is connected to the second port, the first unit copies all signals from the second port to the first port and copies at least those signals addressed to the second unit, and preferably all signals, from the first port to the second port, while responding to signals addressed to the first unit on the first port. This allows the second unit to function correctly when it is physically connected to the second port.

According to a third aspect of the invention, the second unit is a device of a first type, and the first unit converts between communications on the second port with the second unit and communications on the first port representative of a unit of a second type different from the first type. This allows units of the first type to be used where the machine controller does not recognise units of the first type but does recognise units of the second type.

According to a fourth aspect of the invention, the first unit communicates with the controller by representing values in a first denomination and the first unit communicates with the second unit by representing values in a second denomination, and the first unit converts between the first and second denominations.

Arrangements embodying the invention will now be described by way of example with reference to the accompanying drawings, in which:

FIG. **1** is a schematic diagram showing the connections between a vending machine controller, a changer and further money handling units in embodiments of the present invention;

FIG. **2** is a schematic diagram showing the internal electronic arrangement of the changer;

FIG. **3** is a cut-away front view of the changer showing the coin-handling apparatus;

FIG. **4** is a front view of a vending machine incorporating the changer; and

FIG. **5** is a partial cut-away side view of the front panel of the vending machine of FIG. **4**.

As shown in FIG. **1**, a changer **110** in an embodiment of the present invention has a first port P1 for connection to a vending machine controller **130** via a communication line C. The changer **110** receives and validates coins or tokens and indicates the value of the coins accepted to the controller **130**, over the first port P1. The changer **110** also dispenses accepted coins as change, in response to commands received from the controller **130** over the first port P1. These commands may indicate the value of change to be given, or the specific coins to be given as change, according to the interface standard used over the first port P1.

The changer **110** also has a second port P2 which provides an interface compatible with the MDB protocol. According to this protocol. payment units of different types can be connected to a host (in this case, the changer **110**) without having to reconfigure or reprogram the host. Instead, the host interrogates all connected devices, each of which responds with a code indicating the type of that device, the codes being defined by the MDB standard. The host is pre-programmed with a set of commands and responses appropriate to each type of device. The devices supported include a card acceptor **70**, a bill validator **100** and a change dispenser **105**. Multiple devices of different types or of the same type can be connected and operated simultaneously via a bus connection to the changer **110**. The pin connections of the second port P2 are as follows:

TABLE 1

Second Port MDB Pinout

Pin	Function
1	34 V DC (Supply from Changer)
2	0 V DC (Supply Return)
3	Not Connected
4	Master Receive (input to changer)
5	Master Transmit (output from changer)
6	Common (Signal Return)

The second port P2 includes a physical connector **440**, such as a socket, complying with the MDB standard, and an interface adaptor **430**.

The changer **110** can be configured to implement any one of a number of different standard interfaces over the first port P1 in order to match the interface of the controller **130** to which the changer **110** is to be connected. A separate interface adapter is provided within the changer **110** for each respective standard supported by the changer. A cable connector and a port connector appropriate for the desired standard is plugged into the appropriate interface adapter. A controller within the changer recognises which interface adapter is in use and automatically runs protocol software appropriate to that standard. The software for each standard is stored within the changer **110**.

FIG. **2** shows the electronic connections within the changer **110**. A microcontroller **400** is connected to the first through fourth interface adapters **410, 412, 414, 416** which convert between the low voltage inputs and outputs from the microcontroller **400** and the input and output voltages required respectively by first to fourth interface standards with which the first port P1 complies according to the configuration of the changer. A first port connector **420** which complies with the physical requirements of the required interface is connected to the appropriate one of the interface adapters **410** to **416**. The first port connector **420** may be a plug connector extending from the changer **110** on a cable, the other end of which is connected to the appropriate interface adapter **410, 412, 414, 416** by a plug and socket connection.

The first supported interface is an MDB compatible interface, which implements an MDB protocol to Level **3** of the First Version, Aug. 19, 1994, so that the changer **110** can interoperate with the controller **130** if the latter operates to level **2** or **3**. The controller **130** issues commands to pay out coins either of a specified type or to a specified value, to change the mode of operation of the changer, and to request specific status information from the changer. The MDB protocol supports 16 different coin values, with the maximum value of the largest coin being 255 times the value of the smallest coin. The first port connector **420** is connected to the first interface adapter **410**, and comprises a six-way MDB connector, with pins connected as follows:

TABLE 2

MDB Connector Pinout

Pin	Function
1	34 V DC (supply from Host)
2	0 V DC (supply return)
3	Not Connected
4	Master Receive (Output from Changer, input to Controller)
5	Master Receive (Input to Changer, output from Controller)
6	COMMON (Signal return)

The MDB signal lines operate on a current loop principle. The host (controller **130**) acts as a current source for both the Master Transmit and Master Receive circuits. If the host sources current into the Master Receive loop, all connected devices can receive the transmitted data. In order to transmit, a device closes the loop on the Master Receive line, which is detected by the host.

The second interface supported by the second interface adapter **412** complies with the Executive protocol defined by the Mars Electronics International Protocol A specification (MEI Reference No. 10102-000304001-PS). The first port connector **420** then comprises an Executive Communications Connector and an Executive Power Connector, with pin connections as follows:

TABLE 3

Executive Communications Connector

Pin	Function
1	TX+
2	RX–
3	RX+
4	TX–
5	unused
6	unused
7	unused
8	unused
9	screen

TABLE 4

Executive Power Connector

Pin	Function
1	24 V AC
2	24 V AC
3–15	Not Connected

The third interface supported by the third interface adapter **414** complies with the BDV protocol defined by standard BDV001 produced by the BVD committee. The port connector is AMP Type 350720-1 (Universal Part Number). The pin connections are as follows:

TABLE 5

BDV Pinout

Pin	Function
1	DC Return
2	24 V DC
3	unused
4	unused
5	TX+
6	TX–
7	RX+
8	RX–
9	Screen

The fourth interface adapter **416** implements both the European Electromechanical interface defined by the Mars

Electronics International specification 'European Single Price and Four Price Electro-Mechanical Interface' and the US electromechanical interface as defined in 'United States TRC One Price Electro Mechanical Interface'. The shape and pinout of the connector varies according to the type of the electromechanical machine. Various parameters of the electromechanical interface are configurable by the operator.

The changer **110** receives power from the controller **130** over the first port P1. The microcontroller **400** detects to which of the interface adapters **410** to **416** power is applied, identifies therefrom the type of interface in use. Software appropriate to that interface is then automatically loaded into the microcontroller **400** from a store within the changer **110**, such as an EPROM. The software implements the appropriate protocol.

Further inputs I to the microcontroller **400** are connected to sensors for sensing the presence and/or properties of coins received by the changer **110**. For example, some of the sensors may be used to sense properties of received coins to determine whether they are genuine, others detect the progress of a coin through the mechanism, while others detect the level of coins present in coin tubes from which change is dispensed. Further outputs O from the microcontroller **400** are connected to mechanisms for releasing coins to be dispensed and directing the coins into coin tubes or a reject path according to their sensed properties.

When the MDB protocol is implemented over both the first port P1 and the second port P2, further MDB compatible money handling units may be connected either to the bus connection B to the second port P2, or to the bus connection to the controller **130**. The microcontroller **400** detects whether a money handling unit is connected to the second port P2 by sending a 'POLL' command on the Master Transmit line. If no response is received within the standard time-out period, it is assumed that there are no units connected, and the microcontroller **400** only handles communications over the first port P1.

If a unit is detected as being connected, the microcontroller **400** echoes all MDB signals received on the second port P2 to the first port P1, and echoes all MDB signals received on the first port P1 to the second port P2. Preferably, the received signals are decoded, and the code values are stored at least temporarily in memory before being re-encoded without alteration, and then output. As the MDB standard is based on a bus connection, the additional unit therefore operates as if it were connected to the bus connection of the controller **130**. This mode of operation ensures that additional MDB devices will work correctly regardless of whether they are connected to the controller **130** or to the changer **110**.

In an alternative, the second port P2 implements a version of the MDB protocol not supported over the first port P1, for example to support units not recognised by the version of the MDB protocol implemented by the controller **130**. In that case, the microcontroller **400** only echoes those MDB signals common to both protocols. In response to a 'POLL' command from the controller **130**, the microcontroller **400** sends a 'POLL' command to the additional unit on the second port P2. If the additional unit responds with a code indicating a device type not supported by the controller **130**, the microcontroller **400** replaces this with a code indicating a similar device type supported by the controller **130**. The microcontroller also converts signals from the additional unit, which do not form part of the protocol supported by the controller **130**, to signals which are recognised by that protocol. For example, if the additional unit is a receiver for an electronic 'purse' or smartcard from which payments can be both deducted and added, the changer **110** may identify this receiver as a prepaid or debit card to which payments cannot be made. In this way new types of payment can be used, albeit with limited functionality.

However, when the MDB protocol is not enabled over the first port P1, the microcontroller **400** communicates with the controller **130** over the first port P1 using a different protocol from that used to communicate with the additional money handling device or devices connected to the second port P2. The microcontroller receives signals in the MDB protocol over the second port P2 and converts the received signals into signals in the protocol used over the first port P1 and vice versa, using a set of conversion rules forming part of the program stored in the changer **110** and run on the microcontroller **400**. The controller **130** is not able to communicate independently with the additional unit, so that the microcontroller converts any information generated from the additional money handling device so that it appears to the controller **130** to have been generated by the changer **110** and is in a format decodable by the controller **130**.

In one example, a bill validator arranged to receive and validate Euro banknotes is connected via the second port P2 to the changer **110**, which is arranged to receive and dispense British Sterling coins. The smallest bill recognised by the validator is a five Euro note. and the validator outputs the value of a recognised bill to the second port P2 in units of five Euros. For example, if a twenty Euro bill is validated, a value byte will be output with a value of 4. The changer **130** accepts 5, 10, 20, 50 pence and £1 coins, and outputs values over the first port P1 in units of 5 pence. The value of these units is set by a predetermined scaling factor SF, which scaling factor is stored within the controller **130**.

For example, if a 50 pence coin is validated, this will be represented as **10** units. Hence, the units output by the changer **110** are not equal in value to the units output by the bill validator. The microcontroller **400** converts the units of the bill validator to those of the changer **110** by multiplying by a factor input by the operator. In this case, if the exchange rate for one Euro is 70 pence, the factor will be 1/70 (approximately 0.014), since 5 Euros/70=5 pence.

This factor is also used by the microcontroller **400** to convert commands including a value to the appropriate units. For example, to prevent acceptance of bills greater than 5 Euros, the microcontroller **400** sends a command over the second port P2 indicating the maximum value to be accepted, and indicates the value as '1'. This command may be issued in response to a command from the controller **130** to limit the amount of accumulated credit to £4 sterling. The microcontroller **400** infers from the value of the factor that the bill validator should not accept more than 5.71 Euros, which is rounded down to an integral number of units, in this case one unit.

The changer **110** may accumulate credit before communicating to the controller **130**. For example, the controller **130** may indicate to the changer **110** the value at which the machine vends, and the changer **110** may then accumulate credit until the value is reached or exceeded, at which point the changer **110** dispenses any change due and indicates to the controller **130** that a vend should be made. If an additional money receiving unit, such as a bill validator or card reader, is connected to the second port P2, the changer **110** accumulates credit from that unit in addition to the value of the coins received by the changer **110**. For example, if the additional unit is a bill validator arranged to receive and validate Euro banknotes, as in the example above, the validator may receive a five Euro bill and the changer **110**

may receive a £1 coin, for a vend price of £4. The microcontroller **400** converts the one unit of value indicated on the second port P2 to 70 units of 5 pence, and adds the 20 units of 5 pence representing the £1 coin validated by the changer **110**, to give 90 units. The vend price is 80 units, so the microcontroller **400** indicates on the first port P1 that a vend has been paid for, and determines how the 10 units of change should be dispensed. For example, if the microcontroller **400** detects that 50 pence coins are present in one of the coin tubes of the changer **110**, one coin is dispensed from that tube. If change cannot be given to the exact value of overpayment, the microcontroller **400** controls the dispensing of coins as near as possible below the value of the overpayment.

As the second port P2 provides an MDB bus connection B, an additional change dispensing unit may be connected to the second port P2 in addition to a bill validator or card reader, and the microcontroller **400** interrogates the devices connected to the second port P2 to determine their type. For example, a Euro coin dispenser may be connected to the second port P2 and the microcontroller **400** may operate in a mode in which change is dispensed in Euros. The Euro coin dispenser communicates in units of 5 cents (100 cents=1 Euro). Therefore, instead of dispensing a 50 pence coin as in the example above, the microcontroller **400** signals to the Euro coin dispenser to dispense 14 units, which is the equivalent of 50 pence rounded down to the nearest whole number of units.

Further details of the changer of the changer **110** are illustrated in FIG. 3. The changer comprises a coin validator **200**, a coin separator **205** and a coin storage region **207**. The coin validator **200** receives inserted coins **210** through an opening **215**. The coin **210** travels along ramp **220** in the coin validator **200** past sensors such as those shown at **225**. Suitable arrangements for sensors **225** include those described in GB 1 397 083, GB 1 443 934, GB 2 254 948 and GB 2 094 008 which are hereby incorporated by reference. The electrical signals generated by the sensors **225** contain information corresponding to the measured characteristics of the coin, such as a coin's diameter, thickness, metal content and electromagnetic properties. Based on these electrical signals, the microcontroller **400** is able to discriminate whether the coin is acceptable, and if so, the denomination of the coin **210**.

If the coin **210** is unacceptable, the microcontroller **400** controls a gate **235** to direct the unacceptable coin **210** to a reject chute **240**. In the alternative, acceptable coins **210** are directed to the coin separator **205** by the gate **235**. The coin separator **205** may have a number of gates **245**, **247**, **249**, **251** arranged along a ramp **253** and also controlled by signals from the microcontroller **400**, for diverting the coin **210** from the ramp **253**. The coin **210** may be diverted into respective containers **262**, **264**, **266** and **268**, or the coin **210** may be allowed to proceed along ramp **253** to a path **258** leading to a cash box.

Each of the containers **262**, **264**, **266** and **268** is in the form of a coin tube arranged to store a vertical stack of coins of a particular denomination. Although only four containers are shown, any number may be provided.

The coin tubes are arranged within a removable cassette **269**; such removable cassettes are well known in the art. As an example, a removable cassette is described in GB 2 246 897 A, the contents of which are incorporated herein by reference. The removable cassette is marked with a code, which indicates the denominations that are accommodated by the tubes within the cassette. The code is input using the keypad **90** on the changer **110** to inform the mechanism which cassette and tubes have been installed. Alternatively, the design may be such that the mechanism automatically recognises the type of cassette when it is inserted, or else the information could be provided remotely, or on a card.

The changer **110** may alternatively use passive routing techniques, such as those well known in the vending machine art, instead of the gates **245–251** for diverting the coin **210** from the ramp **253**. Examples of suitable alternative configurations for the coin separator **205** are described in U.S. Pat. Nos. 3,844,297 and 4,106,610, which are hereby incorporated by reference.

A dispenser **270** associated with the coin tubes **262–268** is operable to dispense coins from the containers when change is to be given to a customer by the changer **110**, under the control of the outputs O from the microcontroller **400**. The dispensed coins are delivered to the coin return **80** for collection. Suitable dispensers **270** include those described in U.S. Pat. Nos. 3,814,115 and 4,367,760, which are hereby incorporated by reference. An alternative configuration may use, instead of the changer **110**, a coin mechanism that does not pay out change. In such a configuration, a separate pre-loaded coin pay out device, such as those well known in the gaming machine art, may be used to pay out change.

A specific application of an embodiment of the invention is described below with reference to a vending machine, but this is not intended to be a limitation on the application of this invention.

FIG. **4** illustrates a vending machine **1** which contains a variety of products **10** to be dispensed which are stored in an area inaccessible to customers, such as behind a glass panel. Each product **10** is retained by a product delivery apparatus **20** which is selectively actuable to dispense the product into a delivery area **30** that is accessible to the customer. Suitable product delivery apparatus **20** includes vend motors and solenoids as well as others well known in the art. Examples of such apparatus include those described in U.S. Pat. Nos. 4,458,187 and 4,785,927, which are hereby incorporated by reference.

A control panel **40** of the vending machine **1** contains a coin slot **50** and a banknote or bill insert slot **60** which accept currency to initiate a vend operation. The control panel **40** further contains the card acceptor **70** to enable customers to initiate a transaction with a credit or debit card. In addition, an electronic purse device in the form of a card may be inserted into the card acceptor **70** to initiate a transaction. The term "electronic purse device" is used herein to denote a token or card possessing an electronic circuit, a magnetic strip or other data storing medium or circuitry, for retaining a credit value. An electronic purse device may be in one of a variety of shapes, including a key or coin, as well as a card. Such devices may be used as currency in a variety of conventional automatic transaction systems.

A coin return **80**, a bill pay out recess **85** and an item selector such as a keypad **90** are also provided in the control panel **40**. A display **95** on the control panel **40** provides instructions and information to the customer. Suitable displays **95** include dot-matrix displays, selectively activatable message lights, an electronic scrolling message, or other displays capable of operating in the environmental conditions to which automatic transaction systems are typically exposed.

A customer may initiate a transaction by depositing coins or bills of particular denominations in the slots **50** or **60**, respectively. The customer may also insert an electronic purse device, or a debit or credit card in the card acceptor **70** to initiate a transaction. Once sufficient payment has been